MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 3, 2017/2018 SESSION**

## PTH 0016 – MODERN PHYSICS AND THERMODYNAMICS

(All sections / Groups)

4 JUNE 2018
9.00 a.m. – 11.00 a.m.
(2 Hours)

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**INSTRUCTIONS TO STUDENTS**

1. This question paper consists of 4 pages with 4 questions and an appendix.
2. Answer **ALL** questions.
3. Write your answers in the Answer Booklet provided.

## Question 1

a) Transverse waves on a string have wave speed of 8.00 m/s, amplitude of 0.07 m, and wavelength of 0.32 m. The waves travel in the negative $x$-direction, and at $t = 0$ s, the particle at $x = 0$ m has maximum upward displacement.

i) Determine the wave number and the angular frequency of the waves. [2 marks]
ii) Write the wave function describing these waves. [1 mark]
iii) Find the displacement of the particle at $x = 0.36$ m at time $t = 0.15$ s. [1 mark]
iv) Calculate the time elapsed from the instant in part (iii) until the particle at $x = 0.36$ m next has maximum upward displacement. (Hint: Use antinodes concept). [2 marks]

b) The human vocal tract is a pipe that extends about 17 cm from the lips to the vocal folds (also known as "vocal cords") near the middle of your throat. The vocal folds behave like the reed of a clarinet, and the vocal tract acts like a stopped pipe. Estimate the first three standing wave frequencies of the vocal tract. The speed of sound in air is 344 m/s. (The answers are only an estimate, since the position of lips and tongue affects the motion of air in the vocal tract). [3 marks]

c) Two loudspeakers, A and B, are driven by the same amplifier and emit sinusoidal waves in phase. Speaker B is 12.0 m to the right of speaker A, as shown in **Figure Q1(b)** below. The frequency of the waves emitted by each speaker is 688 Hz. You are standing between the speakers, along the line connecting them, and are at a point of constructive interference. Calculate the distance you must walk toward speaker B to arrive at the first point of destructive interference. The speed of sound in air is 344 m/s. [2 marks]

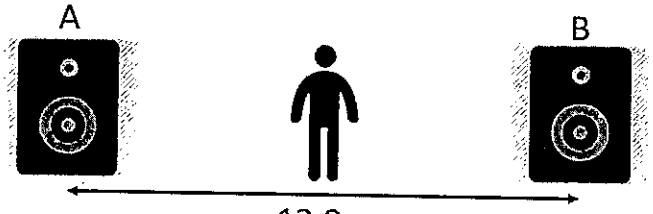


**Figure Q1(b)**

d) A stationary police car emits a sound of frequency 1300 Hz that bounces off a car on a highway and returns with a frequency of 1370 Hz. The police car is right next to the highway, so the moving car is driving directly toward or away from it. Use the speed of sound in air 344 m/s.

i) Determine if the car is moving toward or away from the police car. [1 mark]
ii) Calculate the speed of the car. [3 marks]

## Question 2

a) A 1.50 cm gold ring is placed 20.0 cm from a concave mirror with radius of curvature 30.0 cm. Calculate:

i) the focus length of the concave mirror. [1 mark]
ii) the position of the image. [3 marks]
iii) the magnification. [1 mark]
iv) its height of the image. Explain its sign. [2 marks]

**Continued...**

b) Light with a wavelength of 440 nm illuminates a double slit with a spacing of 0.50 mm. A screen is place 1.5 m from the slit. Calculate the angular separation (in radian) of the first order bright fringes. [3 marks]

**Question 3**

a) i) Metal 1 has a larger work function than metal 2. Both are illuminated with the same short-wavelength light. Do electrons from metal 1 have a higher speed, a lower speed or the same speed as electrons 2? Explain. [2 marks]

ii) A photoelectric effect experiment finds a stopping potential of 1.93 V when light of wavelength of 200 nm is used to illuminate the cathode. With reference to **Table Q3(a)** below, determine the type of metal the cathode is made from. [2.5 marks]

| Element | $E_o$ (eV) |
|---|---|
| Potassium | 2.30 |
| Sodium | 2.75 |
| Aluminium | 4.28 |
| Tungsten | 4.55 |
| Iron | 4.70 |

**Table Q3(a). The work functions for some metals**

b) **Table Q3(b)** shows the atomic mass of some elements. Compute the binding energy of the reactants and of the products in the nuclear fusion reaction below:

$$^2H + ^6Li \rightarrow ^4He + ^4He$$ [5.5 marks]

| Elements | Atomic mass |
|---|---|
| Proton | 1.007825u |
| Neutron | 1.008665u |
| Hydrogen | 2.014102u |
| Lithium | 6.015121u |
| Helium | 4.002602u |

**Table Q3(b). Atomic mass for some elements**

**Continued...**

**Question 4**

a) If 200 $cm^2$ of water at 25 °C is poured into a 150 g glass cup initially at 25 °C. Calculate the final temperature T of the water and glass when equilibrium is reached, assuming no heat flows to the surrounding. Given specific heat of water and glass are 4186 $Jkg^{-1}°C^{-1}$ and 840 $Jkg^{-1}°C^{-1}$ respectively. [3 marks]

b) The Sun has a surface temperature of 5800 K and radius of 700000 km. Calculate the total energy radiated by the Sun in 24 hours. Assume the Sun emissivity is 1. [3 marks]

c) An ideal gas is compressed at constant pressure of 0.8 atm from 9.0 L to 2.0 L. 400 J of thermal energy is released in the process. Calculate the:
   i) work done by the gas. [3 marks]
   ii) change in the internal energy of the gas. [3 marks]

d) Name the following thermodynamic changes.
   i) A gas expands or compressed at constant temperature. [1 mark]
   ii) A gas undergoes expansion or compression in which no heat enters or leaves the system. [1 mark]
   iii) A gas undergoes a process in which the pressure is kept constant. [1 mark]

**Continued...**

# APPENDIX

## LIST OF PHYSICAL CONSTANTS

| | | | |
|---|---|---|---|
| Electron mass, | $m_e$ | = | $9.11 \times 10^{-31}$ kg |
| Proton mass, | $m_p$ | = | $1.67 \times 10^{-27}$ kg |
| Neutron mass, | $m_n$ | = | $1.67 \times 10^{-27}$ kg |
| Magnitude of the electron charge, | $e$ | = | $1.60 \times 10^{-19}$ C |
| Universal gravitational constant, | $G$ | = | $6.67 \times 10^{-11}$ N m$^2$ / kg$^2$ |
| Universal gas constant, | $R$ | = | 8.314 J/mol K |
| Hydrogen ground state, | $E_0$ | = | 13.6 eV |
| Boltzmann's constant, | $k_B$ | = | $1.38 \times 10^{-23}$ J/K |
| Compton wavelength, | $\lambda_c$ | = | $2.426 \times 10^{-12}$ m |
| Planck's constant, | $h$ | = | $6.63 \times 10^{-34}$ J s |
| | | = | $4.14 \times 10^{-15}$ eV s |
| Speed of light in vacuum, | $c$ | = | $3.00 \times 10^8$ m/s |
| Stefan-Boltzmann constant | $\sigma$ | = | 5.67 × 10-8 Wm$^{-2}$K$^{-4}$ |
| Rydberg constant, | $R_H$ | = | $1.097 \times 10^7$ m$^{-1}$ |
| Acceleration due to gravity of earth, | $g$ | = | 9.80 m/s$^2$ |
| 1unified atomic mass unit, | 1 u | = | 931.5 MeV/$c^2$ |
| | | = | $1.66 \times 10^{-27}$ kg |
| 1 electron volt, | 1 eV | = | $1.60 \times 10^{-19}$ J |
| Avogadro's number, | $N_A$ | = | $6.02 \times 10^{23}$ mol$^{-1}$ |
| Threshold of intensity of hearing, | $I_0$ | = | $1.0 \times 10^{-12}$ W/m$^2$ |
| Coulomb constant, | $k = \frac{1}{4\pi\varepsilon_0}$ | = | $9.0 \times 10^9$ N m$^2$/C$^2$ |
| Permittivity of free space, | $\varepsilon_0$ | = | $8.85 \times 10^{-12}$ C$^2$/N m$^2$ |
| Permeability of free space, | $\mu_0$ | = | $4\pi \times 10^{-7}$ T m/A |
| 1 atmosphere pressure, | 1 atm | = | $1.013 \times 10^5$ N/m$^2$ |
| | | = | $1.013 \times 10^5$ Pa |
| Wien's displacement constant | | = | $2.90 \times 10^{-3}$ mK |
| Speed of sound in air | | = | 343 m/s |
| Refractive index of air/vacuum | $n$ | = | 1.0 |
| Earth: Mass, | $M_E$ | = | $5.97 \times 10^{24}$ kg |
| Radius (mean), | $R_E$ | = | $6.38 \times 10^3$ km |
| Moon: Mass, | $M_M$ | = | $7.35 \times 10^{22}$ kg |
| Radius (mean), | $R_M$ | = | $1.74 \times 10^3$ km |
| Sun: Mass, | $M_S$ | = | $1.99 \times 10^{30}$ kg |
| Radius (mean), | $R_S$ | = | $6.96 \times 10^5$ km |
| Earth-Sun distance (mean), | | = | $149.6 \times 10^6$ km |
| Earth-Moon distance (mean), | | = | $384 \times 10^3$ km |

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